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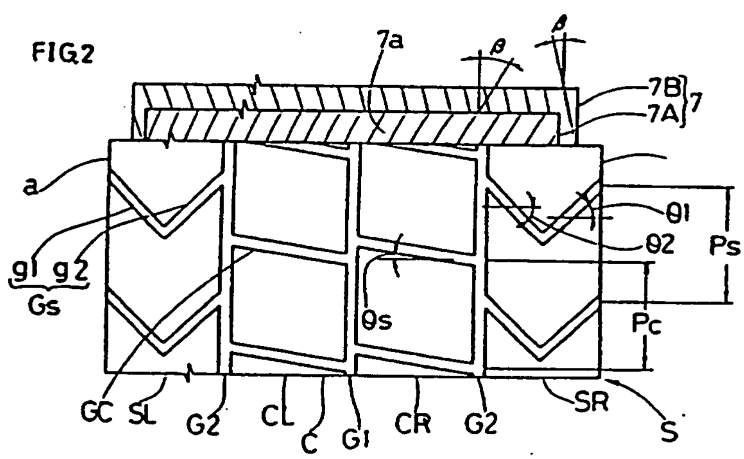
(54) Pneumatic radial tyre.

(57) A pneumatic radial tyre comprising a carcass (6) and a belt (7) comprising belt plies (7A, 7B) composed of steel belt cords (7a) wherein at least two circumferential grooves (G) are constructed in the tread part (2) extending continuously in the direction of the tyres equator (CO) and lateral grooves in some parts defined by dividing the tread part (2) in the axial direction of the tyre into approximately three or four equal areas. (SL, CL, CR, SR). The tyre prevents one side drifting of a car in driving and improves the straight forward driving performance.

FIG2



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PNEUMATIC RADIAL TYRE

This invention relates to a pneumatic radial tyre, and more particularly to a pneumatic radial tyre of improved steerability for passenger cars.

Radial tyres are widely used to give good steering stability, ride comfort, wear rates and so on. However, tyres which are superior in a straight-forward driving performance by preventing drifting to one side of a car in order to increase the driving safety of a car are now being demanded. Conventionally, one-side drifting is considered to be caused by the so-called conicity in which the circumferential length of the belt layer in the right and left sides of the tyre are different from each other. Therefore, various methods have been tried to improve the homogeneity in the right and left directions of the tyres axis.

On the other hand, owing to the recent progress in tyre measurement techniques, as shown schematically in Fig. 9, the cornering force, i.e. the lateral force F which is generated in the lateral direction Y of a tyre when a tiny slip angle (α) is given in the running direction X of the tyre and the self-aligning torque SAT which revolves in the direction of the slip angle (a) about the vertical axis Z that passes the centre of a tyre can be measured at a high precision.

Such measurement results are shown by curve K in Fig.10, by plotting the self aligning torque SAT on the axis of abscissas and the lateral torque F on the axis of ordinates. In the curve K, the cases when the slip angle (a) is 0 degrees, + 0.1 degrees or - 0.1 degrees are shown by dots.

From this relation of self-aligning torque SAT and lateral force F, the lateral force F at the crossing point K1 of the curve K and the axis of ordinates, that is, the lateral force F when the self-aligning torque SAT is not generated, can be derived and this is called the residue CF. It is the object of thus invention to provide a tyre which prevents one sided drifting of the car, improves straight line performance and has good aesthetic appeal.

The inventors have found that the residue CF is the tyre characteristic which affects the one-side drifting of the car. In other words, a car drifts to one side when the residue CF is in the plus direction. i.e. the right direction. Thus, the one side drifting characteristics of a car can be evaluated by the direction and the size of the residue CF. In order to prevent the one side drifting of a car, it is required to reduce the residue CF.

The residue CF is generated from the expansion and contraction of the belt in the ground contact zone. A shearing strain in a surface is created in the cross ply belt of a radial tyre by the parallel movement of the cords due to expansion and contraction. Thus the thread rubber generates a steering torque by a shearing in the surface generated together with the strain of the belt ply in the outermost layer of the belt. It is considered that the lateral force F is created by this steering torque. Thus it was found that the residue CF is caused by the belt and depends on the cords quantity of the belt and the inclination of the belt cords.

The cord quantity is defined as N x S which is the product of the total sectional area of one belt cord S (sq.mm) and the number of the belt cords N existing in 10cm in the right angled direction of the belt cords. The rigidity of the belt can be reduced by reducing the cord quantity N x S or by enlarging the inclination angle of the cords to the direction of the tyres equator. This reduces the hoop effect of the belt and the residue CF, thereby controlling the one side drifting of a car.

On the other hand, such a reduction of the rigidity of the belt can improve the ride comfort performance at the same time, which is a basic item required for a car.

Additional experiments were conducted for reduction of the residue CF in a tread having a relatively low belt rigidity. As a result, it was found that good results could be obtained by reducing the inclination of the lateral grooves crossing the circumferential grooves of the tread pattern, that is, positioning the lateral grooves closely in the direction of the tyres axis. However, such a tread pattern does not provide a sufficiently powerful image to customers, lacks aesthetic sense, and tends to decrease the marketability of the product.

In another approach it was found that by reducing the belt cord quantity and enlarging the inclination angle to the direction of the tyres equator, the hoop effect is reduced and the cornering force decreases especially upon turning, thus impeding the steering stability.

It is hence a primary object of the invention to provide a pneumatic radial tyre which prevents one side drifting of a car in driving, improves a straight forward driving performance and reducing the deterioration of steering stability.

In the first and second aspects, as described above, by setting the inclination angle of the lateral grooves to th direction of tyres axis at a small angle, the residue CF can be reduced in a tyre. However, in order to increase the product appeal and the marketability of a tyre, a tread pattern must appeal to the aesthetic sense of customers. But, a pattern of lateral grooves extending in a direction of tyres axis is often

seen to lack powerfulness. Therefore, in order to increase the powerfulness, the inclination should be larger, but on the other hand, a larger inclination accompanies an increase of the residue CF. Therefore, it is required to meet these contradictory requirements.

Consequently, in the first aspect, an increase of the residue CF is prevented and an image of the pattern can be improved by constructing approximately symmetrical lateral grooves in a V shape in at least one outside area and inside area in a tread part divided in the direction of tyres axis approximately into four equal areas which are a left inside area CL, a right inside area CR (combined and called an inside area C), a left outside area SL and a right outside area SR (combined and called an outside area S), with a difference of inclination angles ($|\theta 1-\theta 2|$), of 5 degrees, or less, and thus, offsetting the effects of the lateral grooves in inside and outside areas.

In a second aspect, an increase of the residue CF is prevented and the image of the pattern is improved by constructing approximately symmetrical horizontal grooves in a reverse V shape in the right and left outside areas SL and SR, or the right and left outside areas CL and CR, the inclination angles ($\theta sL,\theta sR$), or ($\theta cL,\theta cR$) which are approximately equal, for example, the difference ($|\theta sL-\theta sR|$), or the difference ($|\theta cL-\theta cR|$) is 5 degrees, or less, and thus offsetting the effects of the lateral grooves in the right and left inside areas, or the right and left outside areas.

In addition to the above, by setting the cord quantity NS at 15.0 or less and the inclination of the belt cords at 21 degrees or more, the rigidity of the belt can be reduced and the ride comfort improved.

In order to obtain compatibility of the steering stability with the one side drifting performance of a car, the present inventors continued further studies based on a conventional pneumatic radial tyre for passenger cars having rows of blocks formed by crossing the lateral grooves in a rib sectioned by plural circumferential grooves having a linear or zigzag shape with extends in a circumferential direction. As a result of the studies, it was found that the contribution rating of lateral grooves to the cornering performance of a tyre is small, and therefore, they hardly affect the steering stability.

Moreover, it was also discovered that the residue CF is reduced by forming the outer lateral grooves in the right and left outside area SL,SR in the reverse direction to the outside belt cords which are the belt cords of the outermost belt ply and with an inclination of 0 to 40 degrees to the direction of the tyre axis.

Prototypes of tyres SA, SB and SC having outer lateral grooves Gs in the outside area S in different directions were produced as shown in Figs 11(a) to (c). The outside belt cords 7a of the outermost belt ply are shown by single dotted broken lines in the Figures. In Fig.11 (a), the outer lateral; grooves Gs are inclined in the same direction as the outside belt cords 7a. In Fig.11 (b), they are formed in the direction of the tyres axis. In Fig.11 (c), they are formed in the reverse direction. The results of measuring the residue CF in such patterns as SA, SB and SC are shown in Fig.13. In the patterns SA, SB and SC, the residue CF's are 14.4 kg, 7.8kg and 3.6 kg respectively. Thus, it was provided that the residue CF of the pattern SC in which the outer lateral grooves Gs are constructed in a different direction to the outside belt cords 7a is reduced.

Fig. 13 shows the residue CF in the cases of patterns CA, CB and CC from Fig.2 in the case of pattern CA the inner lateral grooves Co are inclined in the same direction as the outside belt cords 7a in the inside area C, as shown in Figs. 12 (a), Figs 12(b) and (c) show the pattern CB in which they are inclined in the direction of the tyre axis and the pattern CC in which they are inclined in the reverse direction, respectively. The residue CFs are 5.9 kg 8.1 kg and 12.1 kg, respectively. The absolute value of the residue CF was thus reduced by inclining the inner lateral grooves in the same direction as the outside belt cords 7a.

Thus it was found that the residue CF can be reduced and the one side drifting performance of a car can be improved by inclining the lateral grooves in the reverse direction to the outside belt cords 7a in the outside area S and in the same direction in the inside area C.

Therefore, in the aspect of the invention, outer horizontal grooves Gs constructed in the outside area S are inclined in a different direction to the outside belt cords 7a and at 0 to 40 degrees to the direction of the tyres axis.

In addition, in the third aspect, lateral grooves are inclined in the same direction as the outside belt cords 7a and at an angle of 40 degrees or less to the direction of the tyres axis in the inside area C.

The following description relates to a fourth aspect of the invention. In the case that inner lateral grooves Gc having a larger inclination are constructed in the inside area C, the cornering force upon turning of a tyre generated especially when the slip angle (α) is 1 degree tends to be reduced. Therefore, in some cases, it is not preferable to form inner horizontal grooves Gc having a larg r inclination angle.

Thus, it is required to impose the reducing effect of the residue CF caused by the inside area C on the outside area S.

The inventors considered that the residue CF could be controlled by 6 kg or less in absolute value by setting the circumferential pitch Ps at 20mm or less. Thus the cornering force generated when the slip

angle (a) is 1 degree is larger and steering stability upon turning is improved without relying upon the inner lateral grooves Gc of the inside area C.

To do this they produced prototypes of tyres having different circumferential pitches Ps in the direction of the tyres equator between the outer lateral grooves Gs in the outside area S as shown in Fig 26, and the results of measuring the residue 6F as shown in Fig 27.

Thus, the circumferential pitch Ps is set at 20mm or less in this aspect of the invention.

The next description relates to a fifth aspect.

As described above by providing lateral grooves Gs in the outside area S extending in a different direction to the outside belt cords 7a, the residue CF can be reduced, and the larger the inclination angle Cs, is, the further the residue or can be reduced.

However, it was found that in the case that the inclination (θs) is set at a larger angle, the noise generated by the tread pattern becomes larger. Therefore, when noise characteristics is important, the inclination angle (θs) of the outer horizontal grooves Gs needs to be limited.

Therefore, the controlling method of the residue CF was further studied. The residue CF was measured by changing the maximum length L in the right angled direction to the lateral grooves Gc of a block B formed by the inner lateral grooves Gc formed in a middle area M, dividing the tread part shown in Fig 32 into three equal areas. As known from the results shown in Fig.34, it was found that the residue CF is reduced by reducing the maximum length L gradually. Furthermore, by setting the maximum length L at 10mm or less, the absolute value of the residue CF can be set at 5 kg or less.

Thus, the maximum length L of the block B in the middle area M was set at 10 mm or less.

By this the straight forward driving stability can be improved without affecting the steering stability or noise characteristics.

Moreover, in the third, fourth and fifth aspects of the invention this can be preferably adopted in a tyre having a belt which brings about a strong hoop effect and improves the steering stability, wherein the cord quantity NS is 18.0 or more and the inclination of the belt cords to the tyres equator is 18 degrees or less.

Embodiments of the invention will be described in detail below, in conjunction with the attached drawings in which:-

Fig.1. is a sectional view showing an embodiment of the first invention.
Fig.2. is a plan view showing the pattern for Fig.1
Figs 3 to 6 are plan views showing other patterns,
Fig.7 is a sectional view of a belt ply.
Fig.8 is a sectional view showing an example of a belt cord,
Fig.9 is a perspective view explaining the residue CR
Fig.10 is its diagram
Figs. 11(a) to (c) and 12(a) to (c) are plan view showing patterns used in the experiments.
Fig.13 is a diagram showing the experimental results
Fig.14 is a plan view showing the pattern of one embodiment of the second invention
Figs 15 to 18 are plan views showing other patterns.
Fig. 19 is a plan view showing the pattern of one embodiment of the third invention.
Fig.20 is a plan view showing an example of a pattern for Fig.19.
Figs 21 to 23 are plan views showing other patterns.
Fig.24 is a plan view showing the pattern of a comparison example,
Fig.25 is a plan view showing the pattern of one of the embodiments of the fourth invention,
Fig.26 is a plan view showing an example of another pattern.
Fig.27 is a diagram showing the results of tests.
Figs. 28 and 29 are plan views showing other patterns respectively.
Fig.30 is a plan view showing the pattern of a comparative example.
Fig.31 is a sectional view showing one of the embodiments of the fifth invention.
Fig.33 is a plan view showing an example of the other pattern.
Fig.34 is a diagram showing an example of the test,
Figs 35 and 36 are plan views showing other patterns,

In Figs. 1 and 2, a pneumatic radial tyre 1 of the first invention comprises a carcass 6 extending from a tread part 2 through a side-wall part 3 to a bead part 4 and wrapped around a bead core 5 in each bead a belt 7 is placed radially outside the carcass 6 and inside the tread part 2.

The belt 7 comprises belt plies 7A and 7B of two inside and outside layers which are inclined in mutually reverse directions at an inclination angle (β) of 21 degrees or more to the tyres equator CO of the belt cords. The outermost belt ply cords of the outside belt ply 7A in the embodiment are inclined in the right upper direction to the tyres equator CO as shown in Fig.2. For belt cords 7a, as shown for example in

Fig.8 twisted steel filaments 7b in 2 + 7 x 0.22, 1 x 5 x 0.23 or 1 x 4 x 0.22 relationship may be used.

The cord quantity NS which is the product of the total sectional area S (sq.mm) of one cord, that is, the sum of the sectional areas of the filaments 7b of the cord and the number of cords N in a distance 1 of 10 cm in Fig.7 is 15.0 or less, thereby the rigidity of the belt 7 is reduced and the ride comfort performance is improved in the tyre.

In Fig.2, the tread part 2 is sectioned in the direction of tyres axis into a left inside area CL and a right inside area CR at either side of the tyres equator CO, a left outside area SL and a right outside area SR which extend to the edges a of the tread part.

Outer lateral grooves Gs comprising an outer groove part gl with an inclination angle (θ1) of 45 degrees or less to the axial direction of the tyre and on outer groove part g2 including reversely to the outer groove part gl at an angle (θ2) and forming a V shape with the outer groove part gl are constructed in the right and left outside area S. the difference of the inclinations (θ1) and (θ2) of the outer groove part g1 and the inner groove part g2, (|θ1-θ2|) is set at 5 degrees or less.

Thus, the outer lateral grooves Gs are substantially symmetrical in the direction of tyres axis, and the effect of the residue CF by the inclinations is reduced. This also improves the appearance of the tyre. In addition, in the right and left inside areas C, inner lateral grooves Gc are provided inclined in the right lower direction at an inclination angle (θc) of 5 degrees or less to the direction of the tyre axis.

If the inclination angle (θs) of the outer lateral grooves Gs exceeds 45 degrees pattern noise tends to be caused.

Circumferential grooves G1 and G2 are provided which extend continuously in the direction of tyres equator CO separating the right and left inside area CL & CR and the middle position between the tyres equator CO and the edge of the tread part 2, sectioning the right and left inside areas CL,CR and the right and left outside area SL, SR. The circumferential grooves G (generally called the grooves G1, G2) may be linear grooves or zigzag grooves.

Circumferentially pitches Ps and Pc are the distances between successive outer and inner grooves Gs and Gc in the direction of the tyres equator (CO) are both set at 40 mm or less, preferably 20 mm or less.

Fig.3 shows an embodiment where the inner circumferential groove GC in the inside area C is formed in a V shape.

Fig.4 shows an embodiment where the outer grooves Gs are formed in a V shape and a groove Gc1 extending in the direction of tyres axis and V shaped grooves Gc2 are also formed in the inside areas Cl, CR.

Thus shaped lateral grooves may be formed only in an inside area Gc or only in an outside area Gs or in both.

Thus Figs. 2 to 4 show embodiments where the main grooves G1 and G2 are placed in the parts that section the inside area C and the outside area S, while in the case where two main grooves G2 and G2 are employed, as shown in Fig.5 or in the case that four or more grooves G2A, and G2B are provided employed at regular intervals as shown in Fig.6, the inside area C and the outside area S are considered to be sectioned by a virtual line F on the rib. At least one end of the inner circumferential groove 5 Gc must open to the circumferential or main grooves G. One of the embodiments of the second invention is shown in Fig.1 and 14. description of common elements are parity with the foregoing firstly invention are omitted. The third, fourth and fifth inventions hereinafter are treated in the same manner.

In the right and left outside area S, substantially symmetrical outer lateral grooves GsL and GsR (generally called outer lateral grooves Gs) are separately constructed with reverse inclinations of (θsL) and (θsR) of 20 degrees to the direction of the tyre axis in the direction of the tyres equator (CO).

In addition, in the embodiment, substantially symmetrical inner lateral grooves GcL and GcR (Generally called inner lateral grooves Gc) are separately constructed in the right and left inside areas CL, CR but with reverse inclinations of (θcL) and (θcR) of 30 degrees to the direction of tyre axis. The difference of the inclination angles (|θsL-θsR|) and (|θcL-θcR|) is set at 5 degrees or less.

Thus, the lateral grooves Gs and Gc are symmetrical in the direction of the tyres equator CO and the effect of the residue CF by the inclinations is reduced. The appearance is also improved.

If the inclinations (θsL), (θsR), (θcL) and (θcR) of the outer lateral grooves and Gc exceed 45 degrees, a pattern noise tends to be generated.

Circumferential pitches Ps and Pc which are the distances between the outer and inner lateral grooves Gs and Gc in the direction of the tyres equator (Co) care both set at 40mm or less preferably at 20 mm or less.

Fig.15 shows another embodiment in which the inner lateral grooves Gc of the inside area C are formed in a reverse V shape, and Fig.16 shows still other embodiments in which the outer horizontal grooves Gc are formed in a reverse V shape whilst the other lateral grooves Gs or the horizontal grooves Gc extend in

the direction of the tyre axis.

Thus Figs. 14 to 16 shows embodiments where the main grooves G1 and G2 are constructed respectively in the parts that section the inside area C and the outside area S, while in the case that two main grooves G2 are employed, as shown in Fig.17, or in the case that four or more grooves G2A, and G2B are employed, spaced apart at regular intervals as shown in Fig.18, the inside area C and the outside area S are considered to be sectioned by a virtual line R on the ib. At least one end of the inner circumferential groove Gc must open to a main groove G.

One embodiment of the third invention is shown in Fig.1. and Fig.19.

In the right and left outside areas SL, SR outer lateral grooves Gs with an inclination angle (θs) of 40 degrees or less to the direction of the tyre axis which is opposite to the inclination of the outside belt cords 7a are constructed at spacings in the direction of the tyres equator CO.. In the right and left inside area CL, CR inner lateral grooves Gc with an inclination angle (θc) of 40 degrees or less to the direction of the tyres axis inclined in the right upper direction the same as the outside belt cords 7A are provided. If the inclination exceeds the inclination angle (θs) of the lateral grooves Gs, a pattern noise tends to be generated. In the case that the inclination (θc) of the inner horizontal grooves Gc exceeds 40 degrees, the cornering force upon turning tends to be reduced, and the steering stability tends to be deteriorated.

The circumferential pitches Ps and Pc which are the distances between the outer and inner grooves GS and Gc in the direction of tyres equator CO are set at 40 mm or less respectively, preferably at 20mm or less.

As described above the residue CF can be improved by forming the outer grooves Gs to be reversely inclined to the outside belt cords 7A in the right and left outside areas, SL, SR and the inner grooves Gc to be inclined to the same direction in the right and left inside areas, CR, CL. It is confirmed that the residue CF can be further reduced by setting the circumferential pitches Pc and Ps preferably at 20mm or less.

Fig.20 shows another embodiment where the inclination angle (θs) of the outer grooves Gs is set at 0.

Figs 19, 20 show embodiments where the grooves G1 and G2 are constructed respectively in the parts that section the inside area C and the outside area S, while in the case that two main grooves G2 are employed, as shown in Fig.21, or in the case that four or more main grooves G2A, and G2B are employed spaced laterally at regular intervals as shown in Figs 21 to 23 the inside area C and the outside area S are considered to be sectioned by a virtual line F on the rib. At least one end of the inner circumferential groove Gc is open to the circumferential main grooves G. For the belt cord, the same material as used in the first invention can be employed. However, by setting the cord quantity N S at 18.0 or more, the hoop effect of the belt 7 is increased, and thus, the steering stability is improved. It is the same in the fourth and fifth inventions as well.

The fourth aspect shown in Figs 1 & 25 shows in the right and left outside areas S, SR, SL outer lateral grooves GS which extend in the direction of the tyres equator (CO) with the main part GS1 having a length exceeding 70% of the lateral width of the outside area S in the direction of the tyres axis. the main part Gsl is inclined at an angle (θs) of 40 degrees or less to the direction of the tyre axis and reversely to the outside belt cords 7a.

A short sub part Gs2 extends outwardly in the direction of the tyre axis to the edge a of the tread part 2. If the inclination angle (θs) of the outer lateral grooves Gs exceeds 40 degrees a pattern noise tends to be generated.

In the tread part 2, main grooves G2A are formed on c on either side of the tyres equator CO, and other extending side grooves G2B and G2B are also formed to extend continuously in the direction of the tyres equator in the parts that divide the inside area C and the outside area S from one another.

The circumferential groove C shows as vertical in the figure 26 may be straight grooves or zigzag grooves.

In the inside area C, an inner groove GcA comprises an inner groove part GcA1 extending inwards from the main groove G2A with a inner end ending near the equator of the tyre CO and an outer groove part GcA2 extending outwardly in the direction of tyre axis. Moreover, inner grooves GcB extending from the vertical groove G2B respectively to the inside of the tyre are also arranged parallel to the direction of the tyre circumference. The inner groove GcA and GcB are both inclined in the same direction as the outside belt cords 7a. By setting the inclination angle (θc) to the direction of the tyre axis at 35 degrees or less, the cornering force when the slip angle (α) is 1 degree is prevented from deteriorating, and the steering stability on turning the vehicle is prevented from being reduced.

The circumferential pitch Pc of the inner grooves Gc is set at 40 mm or less, preferably at 20mm or less. In addition, by setting the circumferential pitch Ps of the outer horizontal grooves Gs at 20mm or less, the residue CF is reduced.

Where the two main grooves G2 and G2 are at regular intervals as shown in Fig 28, or four grooves

G2A and G2B are at regular intervals as shown in Fig.29 the inside areas C and the outside areas Ss are delineated by virtual lines F on the ribs. At least one end of the inner grooves Gc opens into the vertical grooves G, and at least one end of the outer grooves Gs opens at the edge a of the tread part or into vertical grooves G.

The fifth aspect is shown in Fig 31 and 32 where a tread part 2 is divided virtually into a middle area M including the tyre equator CO and outward areas N extending to the edges of the tread part. In the outward areas, N, outer grooves Gs are placed at spacings in the direction of the tyres equator (CO) extending towards the direction of the tyres axis with an inclination angle (θn) of 0 degrees. In the middle area M, inner grooves Gc with an inclination angle (θm) of 45 degrees or less to the direction of the tyres axis are formed.

The inner grooves Gc are small grooves of 0.5 to 3mm in width, and the inner grooves Gc provide crossing grooves mutually inclined in two different directions each at approximately 40 degrees, to either side of the direction of the tyres axis. therefore, in the middle area M, multiple rhombic blocks B are formed in an oblique latticed shape. The maximum length L of tyre blocks B in a right angled direction to the groove Gs is set at 10 mm or less. In addition grooves G extend continuously in the direction of the tyres equator is positioned to section the middle area M and the outward areas N into approximately three equal areas. The grooves G may be linear straight grooves or zigzag grooves. the circumferential pitch Ps which is the distance between successive outer lateral grooves Gs in the direction of the tyres equator (CO) is set at 40 mm or less, preferably at 20 mm or less.

By setting the length of the blocks B in the middle area M in a right angled direction to the inner horizontal grooves Gc at 10 mm or less, even when the outer grooves Gs extending in the direction of the tyres axis in the outward area N are constructed to control pattern noises, the residue CF is reduced as mentioned before.

However, the outer grooves Gs are not so limited, and, as shown in Fig. 33, they may be inclined in the direction of the tyre axis at an angle (θn) of such a range that does not increase pattern noise, for example, 15 degrees or less, preferably 10 degrees or less, and more preferably 5 degrees or less.

Figs 32, and 33 show a case where the circumferential grooves G are respectively constructed in the parts that section the middle area M and the outward area N, while three such grooves G1, G2, and G2 may be employed, as shown in Fig 35, or four grooves G2A and G2B may be employed spaced at a regular intervals as shown in Fig.36. In these cases, the middle area M and the outward areas N are sectioned by virtual lines F on the ribs. Inner lateral grooves Gc may be formed not in a latticed shape but also as grooves parallel with the direction of the tyres axis or inclined and not mutually crossing, as shown in Figs 35 and 36.

As a working example a prototype tyre having a size of 175/70R13 was produced and the ride comfort and the residue CF were measured. For the belt cords, steel cords of 1 x 4 x 0.22 were used. the belt was formed in two plies. The test was performed by mounting the tyre on a rim 5J x 13 setting the internal pressure at 2.0 kg/sq.cm, the load at 300 kg and using a flat track tyre test machine supplied by MTS company, USA to measure the residue CF. The residue CF is shown by a residue CF index setting the index of the comparison example at 100 in Table 1 etc. The smaller the residue of Index is, the more preferable the result is. In regard to the ride comfort, by mounting the tyre on a 2,000 cc passenger car, a feel test was conducted by a driver, and an evaluation was made by setting the comparison examples at 100 points. Higher scores show better ride comfort.

A: In regard to the first aspect of the invention, a prototype of a tyre as shown in Table 1, Fig 2 & Fig 3 was produced. The results are also shown in Table 1.

B: In regard to the second aspect of the invention, a tyre as shown in Table 2, Figs 14,15 and 16 was produced. The results are shown in the Table 2.

C: In regard to the third aspect of the invention of a tyre as shown in Table 3, Figs 19 and 20 was produced. The results are also shown in the Table 3. Another tyre having the pattern shown in Fig.24 was also produced for the purpose of comparison.

D: In regard to the fourth aspect of the invention, a tyre as shown in Table 4 and Fig.25 was produced. As a comparative example, another tyre having the pattern shown in Fig.30 was also produced. The results are shown in the Table 4.

E: In regard to the fifth aspect of the invention, a tyre as shown in Table 5 and Fig 32 was produced. The results are shown in the Table 5. The noise characteristic was also evaluated through a feel test by a driver and shown in degrees of noise. Higher scores mean more inferiority in noise characteristics.

Thus, the invention can improve the one-side drifting of a car without sacrificing steering stability.

Table 1

	Em. 1-1	Em. 1-2	Em. 1-3	Em. 1	Co. 1-1	Co. 1-2	Co. 1-3	Co. 1-4	Co. 1-5	Co. 1-6
Pattern	Fig.2	Fig.2	Fig.3	Fig.3	Fig.2	Fig.2	Fig.2	Fig.2	Fig.3	Fig.3
Belt cord										
N×S	12.2	12.2	14.5	14.	15.4	15.4	20.5	20.5	12.2	14.5
Inclination angle	21	25	21	25	21	18	21	18	21	21
Lateral groove in V shape										
Location	Outside area	Outside area	Inside area	Inside area	Outside area	Outside area	Outside area	Outside area	Inside area	Inside area
Inclination angle ($\theta 1$)	35	35	35	35	30	30	20	20	30	20
Inclination angle ($\theta 2$)	35	40	35	40	40	40	40	40	40	40
Inner lateral groove										
Inclination angle (θc)	2.5	2.5			2.5	2.5	2.5	2.5		
Direction	Right lower	Right lower	—	—	Right lower	Right lower	Right lower	Right lower	—	—
Circumferential pitch Pc (mm)	18	18			18	18	18	18		
Outer lateral groove										
Inclination angle (θs)			0	0					10	10
Direction	—	—	Lateral	Later	—	—	—	—	Right upper	Right upper
Circumferential pitch Ps (mm)			18	15					18	18
Riding comfort	107	110	102	10	100	97	95	93	106	102
Residue CF index	80	35	90	50	100	130	110	140	100	120

Em. ; Embodiment
CO. ; Comparative example

Table 2

	Em. 2-1	Em. 2-2	Em. 2-3	Em. 2-4	Co. 2-1	Co. 2-2	Co. 2-3
Pattern	Fig.14	Fig.14	Fig.15	Fig.16	Fig.14	Fig.15	Fig.16
Belt cord							
N×S	12.2	12.2	14.5	14.5	15.4	15.4	20.5
Inclination angle	21	25	21	25	21	18	21
Lateral groove GsL in left outside area							
Inclination angle (θsL)	20	20	0	15	20	20	20
Direction	Right lower	Right lower	—	Right lower	Right lower	Right lower	Right lower
Circumferential pitch Pc (mm)	18	18	18	18	18	18	18
Lateral groove GsR in right outside area							
Inclination angle (θsR)	20	15	0	12	10	0	10
Direction	Right upper	Right upper	—	Right upper	Right upper	—	Right upper
Circumferential pitch Ps (mm)	18	18	18	18	18	18	18
Lateral groove GcL in left inside area							
Inclination angle (θsL)	30	30	30	0	30	30	0
Direction	Right upper	Right upper	Right upper	—	Right upper	Right upper	—
Circumferential pitch Pc (mm)	18	18	18	18	18	18	18
Lateral groove GcR in right inside area							
Inclination angle (θcR)	30	25	30	0	30	30	30
Direction	Right lower	Right lower	Right lower	—	Right lower	Right lower	Right lower
Circumferential pitch Ps (mm)	18	18	18	18	18	18	18
Riding comfort	108	110	103	105	100	96	95
Residue CF index	73	24	78	35	100	160	130

Em. ; Embodiment
CO. ; Comparative example

Table 3

	Em. 3-1	Em. 3-2	Co. 3-1
Pattern	Fig.19	Fig.20	Fig.24
Belt cord			
Material	Steel	Steel	Steel
Number of plies	2	2	2
Cord	1×4×0.22	1×4×0.22	1×4×0.22
N×S	20.5	20.5	20.5
Direction of outside belt cord	Right upper	Right upper	Right upper
Inclination angle	16	16	16
Inner lateral groove			
Inclination angle (θc)	30	30	30
Direction	Right upper	Right upper	Left upper
Circumferential pitch Pc (mm)	18	18	18
Outer lateral groove			
Inclination angle (θs)	30	30	30
Direction	Left upper	Left upper	Right upper
Circumferential pitch Ps (mm)	18	18	18
Steering of outside belt cord	110	105	100
Residue CF index	5	26	100

Em. ; Embodiment
CO. ; Comparative example

Table 4

	Em. 4-1	Em. 4-2	Co. 4-1	Co. 4-2	Co. 4-3
Pattern	Fig.25	Fig.25	Fig.25	Fig.25	Fig.30
Belt cord					
Material	Steel	Steel	Steel	Steel	Steel
Number of plies	2	2	2	2	2
Cord	1×4×0.22	1×4×0.22	1×4×0.22	1×4×0.22	1×4×0.22
N×S	20.5	20.5	20.5	20.5	20.5
Direction of outside belt cord	Right upper	Right upper	Right upper	Right upper	Right upper
Inclination angle	18	18	18	18	18
Inner lateral groove					
Inclination angle (θc)	25	25	25	25	30
Direction	Right upper	Right upper	Right upper	Right upper	Left upper
Circumferential pitch Pc (mm)	18	18	18	18	18
Outer lateral groove					
Inclination angle (θs)	40	40	40	40	30
Direction	Left upper	Left upper	Left upper	Left upper	Right upper
Circumferential pitch Ps (mm)	15	20	30	40	18
Steering of stability	110	105	100	100	100
Residue CF index	24	26	39	49	100

Em. ; Embodiment
CO. ; Comparative example

Table 5

	Em. 51	Em. 5-2	Em. 5-3	Co. 5-1	Co. 5-2	Co. 5-3	Co. 5-4
Pattern	Fig.32	Fig.32	Fig.33	Fig.32	Fig.32	Fig.32	Fig.11(c)
Belt cord							
Material	Steel	Steel	Steel	Steel	Steel	Steel	Steel
Number of plies	2	2	2	2	2	2	2
Cord	1×4×0.22	1×4×0.22	1×4×0.22	1×4×0.22	1×4×0.22	1×4×0.22	1×4×0.22
N×S	20.i	20.5	20.5	20.5	20.5	20.5	20.5
Direction of outside belt cord	Right upper	Right upper	Right upper	Right upper	Right upper	Right upper	Right upper
Middle lateral groove							
Inclination angle (θm)	30	30	30	30	30	30	—
Direction	Crossd	Crossed	Crossed	Crossed	Crossed	Crossed	
Maximum length L (mm)	5	10	10	15	20	30	
Outer lateral groove							
Inclination angle (θn)	Lateral	Lateral	8	Lateral	Lateral	Lateral	35 (θs)
Direction	—	—	Right lower	—	—	—	Right lower
Circumferential pitch Ps (mm)	18	18	18	18	18	10	18
Steering stability	10	105	105	100	95	95	105
Residue CF index	70	80	80	100	135	170	70
Noise characteristic	90	95	105	100	105	110	115

Em. ; Embodiment
CO. ; Comparative example

Claims

1. A pneumatic radial tyre comprising a carcass (6) extending from a tread part though a side wall part (3) to a bead part (4) and wrapped around a bead core (5) and a belt (7), comprising belt plies (7A,7B) of two or more layers composed of steel belt cords (7a) which is placed outside in the radial direction of the carcass (6) and inside the tread part (2) characterised in that at least two circumferentially continuous grooves (G2) are provided in the tread part in the direction of the tyres equator (CO), lateral V shaped grooves (Gs,Gc) in the inside area (C) or an outside area (S) defined by dividing the tread part (2) in the axial direction into approximately four equal areas (SL,CL,CR,SR) which are the right and left inside areas (CR,CL) and the right and left outside areas (SR,SL) that extend to the edges of the tread part, the both sides of the right and left inside areas (CR,CL) being composed of the lateral grooves having an outer groove part inclined at an angle ($\theta 1$) to the axial direction of the tyre with at least one end opening to a circumferential groove (G2) or to an edge of the tread part (2) and an inner groove part inclined reversely to the outer groove part at an angle ($\theta 2$) to the axial direction where the difference between the angle ($\theta 1$) and angle ($\theta 2$) defined by ($|\theta 1-\theta 2|$) is 5 degrees or less.

2. A pneumatic radial tyre according to claim 2,characterised in that the belt plies (7A 7B) are so constructed that the cord quantity NS defined as the product of the total sectional area of one belt cord S (sq.mm) and the number of the belt cords N continuous in 10 cm at a right angled direction to the belt cords (7b) is less than 15.0 and that the angle of the belt cords or the tyres equator is 21 degrees or more.

3. A pneumatic radial tyre comprising a carcass (6) extending from a tread part (2) through a sidewall part (3) to a bead part (4) and wrapped around a bead core (5) and a belt comprising belt plies (7A, 7B) of two or more layers composed of steel belt cords (7a) which are placed outside in the radial direction of the carcass (6) and inside the tread part (2) characterised in that at least two continuous circumferential grooves (G2) are constructed in the tread extending in the direction of the tyre equator (CO), lateral grooves formed in at least one of an inside area (C) and an outside area (S) defined by dividing the tread part the axial direction into approximately four equal areas which are the right and left inside areas (CR,CL) of the both sides of the tyres equator and right and left outside areas (CR,SL) that extend to the edges (a) of the tread part (2) at both sides of the right and left inside areas (CR,CL) and lateral grooves provide a V shape since a right groove part thereof is formed in said right area inclined at approximately the same angle and inclined reversely to an outer groove part thereof formed in said left area with respect to the direction of the axis of the tyre.

4. A pneumatic radial tyre according to claim 3, characterised in that the belt plies (7A, 7B) are so constructed that the cord quantity NS defined as the product of the total sectional area of one belt cord S (sq.mm) and the number of the belt cords N driven in 10 cm in a right angled direction to the belt cords is less than 15.0 and that the angle of the belt cords to the tyres equator is 21 degrees or more.

5. A pneumatic radial tyre comprising a carcass (6) extending from a tread part (2) through a side wall (3) part to a bead part (4) and wrapped around a bead core (7) and a belt (7) comprising belt plies (7A, 7B) of two or more layers composed of steel belt cords which is placed outside in the radial direction of the carcass (6) and inside the tread part (2) characterised in that at least two circumferentially continuous grooves are constructed in the tread part extending in the direction of the tyres equator (CO), lateral grooves formed in an inside area (C) and an outside area (S) defined by dividing the tread part in the axial direction of the tyres into approximately four equal areas which are the right and left inside areas (CR,CL) of the both sides of the tyres equator (CO) and the right and left outside areas (SR,SL) that extend to the (a) of the tread part (2) at both sides of the right and left inside areas (CR,CL) said lateral grooves comprising outer lateral grooves which are positioned in the right and left outside areas (SR,SC) and extending at an angle to the axial direction of the tyre with an inclination of 40 degrees or less reverse to the inclination of the belt cords of the outermost belt ply (7A) and at least one end opening at one of the edges (a) of the tread part (2) and the circumferential grooves (G2) and inner lateral grooves which are positioned in the right and left inside areas (CR,CL) with an inclination of 40 degrees or less inclined in the same direction as the outside belt cords.

6. A pneumatic radial tyre according to claim 5, characterised in that the belt plies are so constructed that the cord quantity NS defined as the product of the toal sectional area of one belt cord S (sq.mm) and the number of the belt cords N driven in 10cm in a right angled direction to the cords is larger than 18.0 and that the angle of the belt cords to the tyres equator is 18 degrees or less.

7. A pneumatic radial tyre comprising a carcass (6) extending from a tread part (2) through a side wall

part (3) to a bead part (4) and wrapped around a bead core (5) and a belt (7) comprising belt plies (7A, 7B) of two or more layers composed of steel belt cords which is placed outside in the radial direction of the carcass (6) and inside the tread part (6) characterised in that at least two circumferentially continuous grooves are provided in the tread part (3) extending in the direction of the tyres equator (CO),lateral grooves (GS) formed in an outside area (S) defined by dividing the tread part into approximately four equal areas which are the right and left inside areas (CR,CL) at both sides of the tyres equator (CO) and right and left outside areas (CR,CL) which extend to the edges (a) of the tread part (2) at both sides of the right and left inside areas (CR,CL) said lateral grooves (GS) comprising main parts (GS1) having a length exceeding 70% of the width of the outside area which are inclined at 40 degrees to the axial direction of the tyre and reversely to the inclination of the belt cords (7) of the outermost belt ply (7A), at least one end of the main parts opening to one of the edges or of the tread part (2) or the said circumferential grooves (G2) and the circumferential pitch of the lateral grooves in a direction of the tyres equator being 20mm or less.

8. A pneumatic radial tyre according to claim 7, characterised in that the belt plies are so constructed that the cord quantity NS defined as the product of the total sectional area of one belt cord S (sq.mm) and the number of the belt cords N in a 10cm width in a right angled direction to the belt cords is larger than 18.0 and that the angle of the belt cords (7a) to the tyres equator (CO) is 18 degrees or less.

9. A pneumatic radial tyre comprising a carcass (6) extending from a tread part (2) through a side wall (3) part to a bead part (4) and wrapped around a bead core 7 and a belt (7) composed of steel belt cords (7a) which is placed outside in the radial direction of carcass (6) and inside the tread part (2) characterised in that at least two circumferential grooves (G2) are constructed in then tread part extending continuously in the direction of the tyres equator (CO), blocks (B) are constructed in a middle part (7) defined by dividing the tread part into approximately three equal areas which are a middle part (M) including the tyres equator (CO) and outside parts (N) which extend to the edges (a) of the tread part (2) to both sides of the middle part (7) the said blocks formed by lateral grooves (GC) extending in the direction crossing the tyres equator (CO) and the maximum length of a block (B) in a right angled direction to said the lateral grooves (GS) is 10mm or less.

10. A pneumatic radial tyre according to claim 9 characterised in that the belt plies (7A, 7B)) are so constructed that the cord quantity NS defined as the product of the total sectional area of one belt cord S (sq.mm) and the number of the belt cords N in a 10cm wide strip in a right angled direction to the belt cords is larger than 18.0 and that the angle of the belt cords (7a) to the tyres equator (CO) is 18 degrees or less.

FIG.1

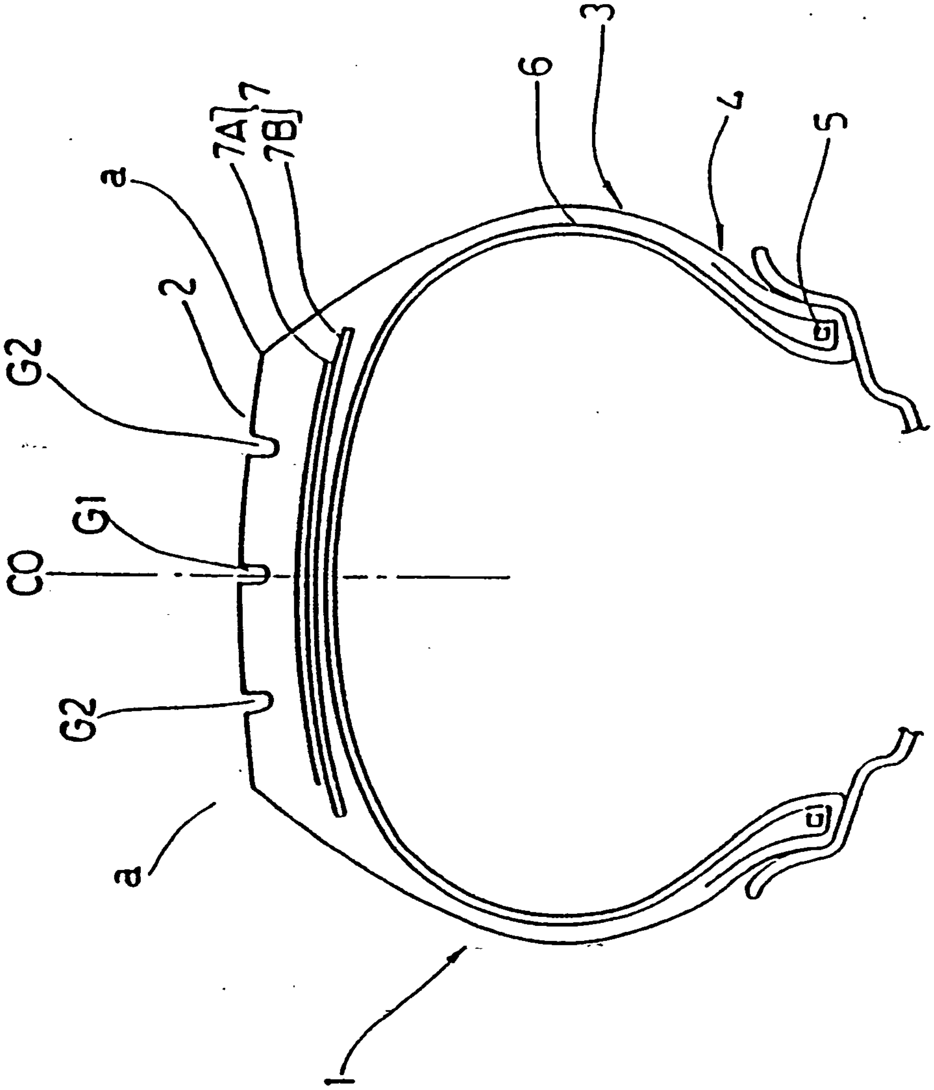


FIG.2

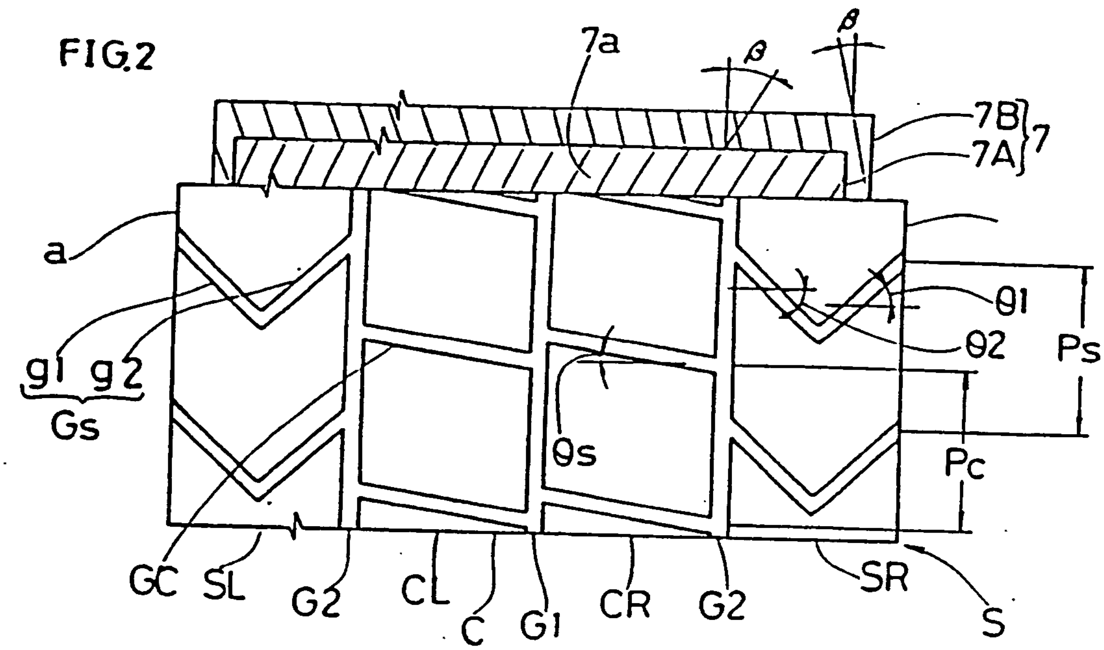


FIG.3

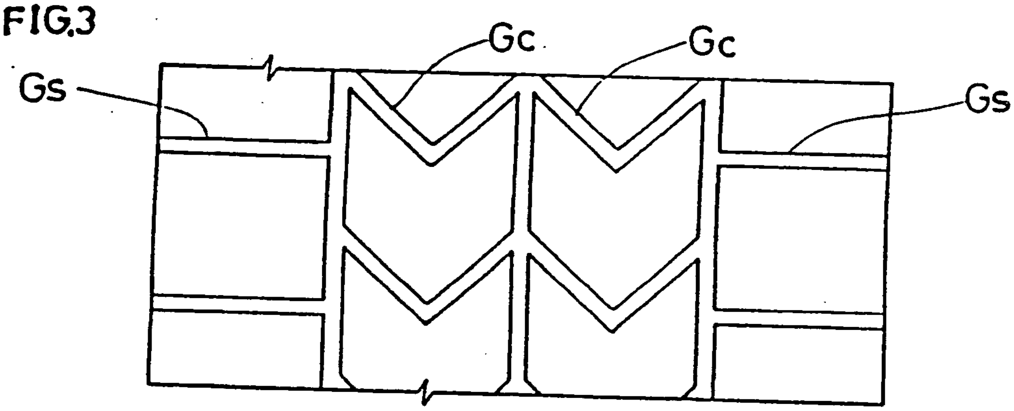


FIG.4

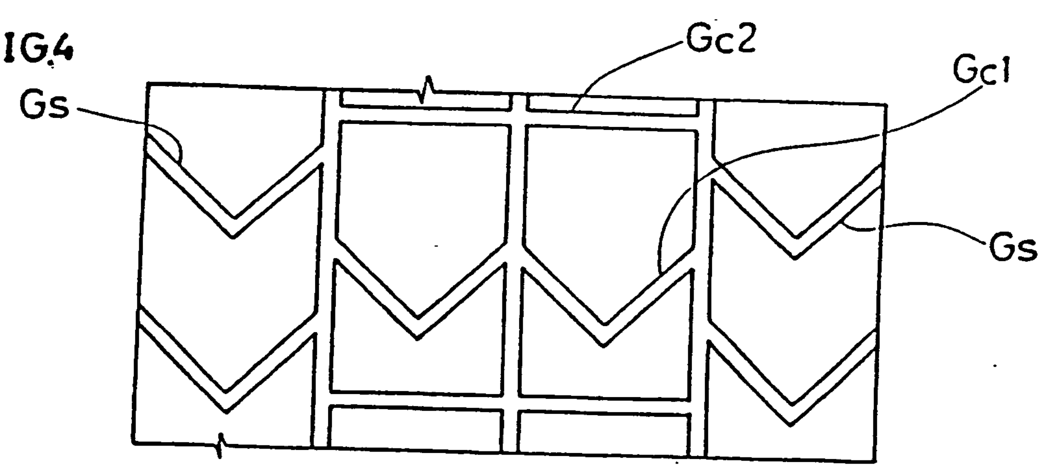


FIG.5

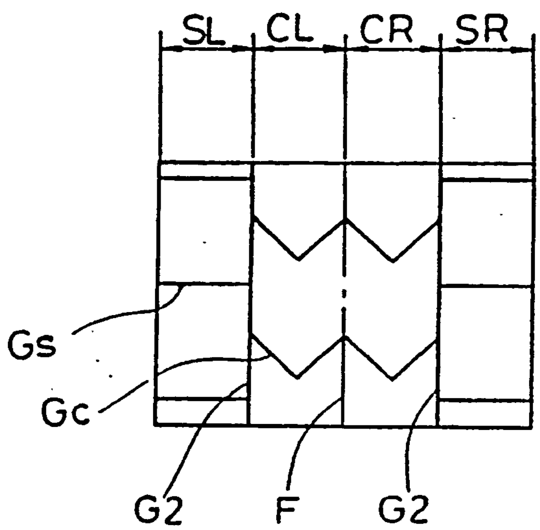


FIG.6

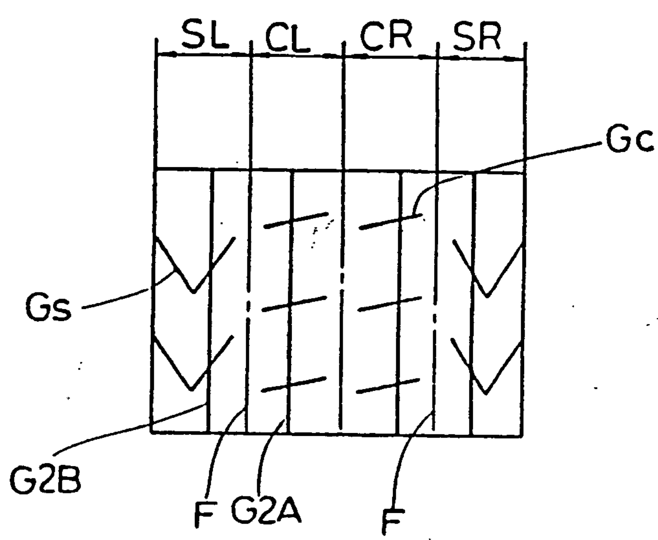


FIG.7

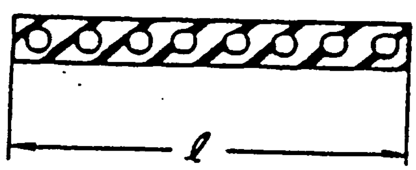


FIG.8

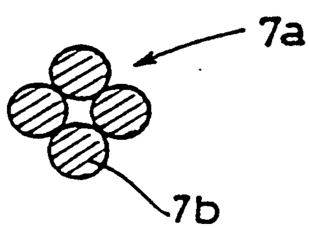


FIG.9

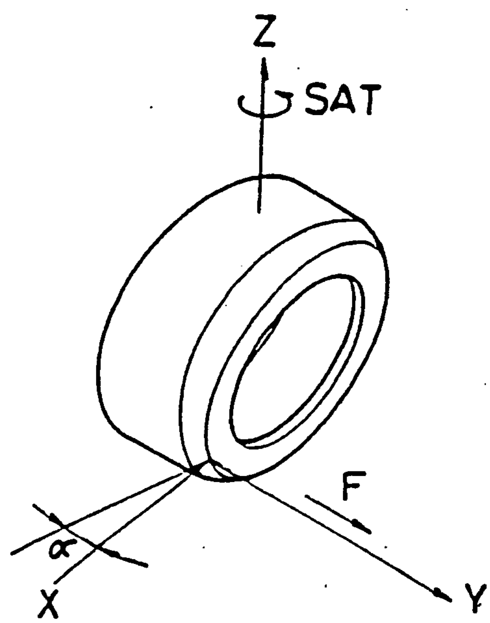


FIG.10

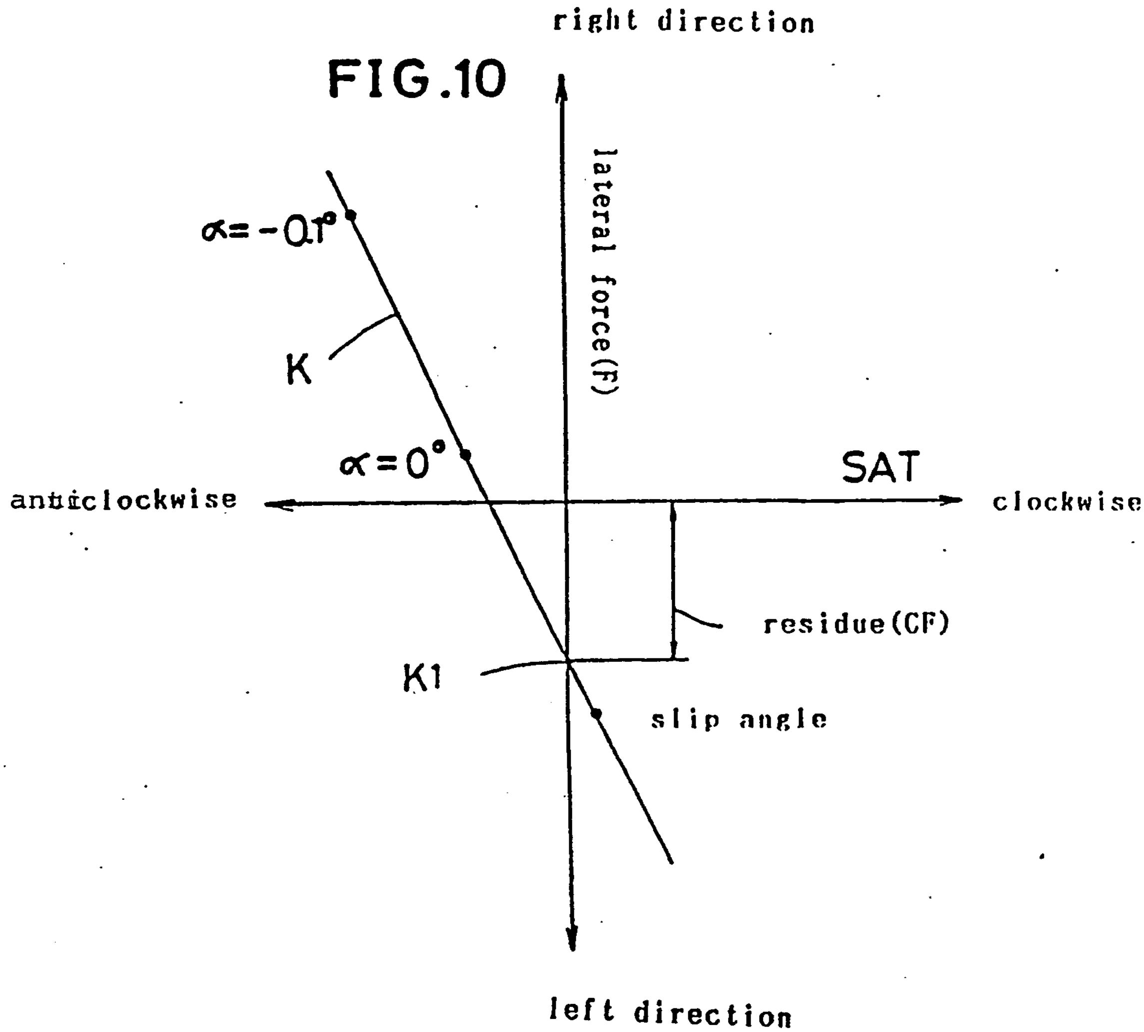

right direction
lateral force(F)
α=-0.1°
K
α=0°
SAT
anticlockwise
clockwise
residue(CF)
K1
slip angle
left direction

FIG.11(a)

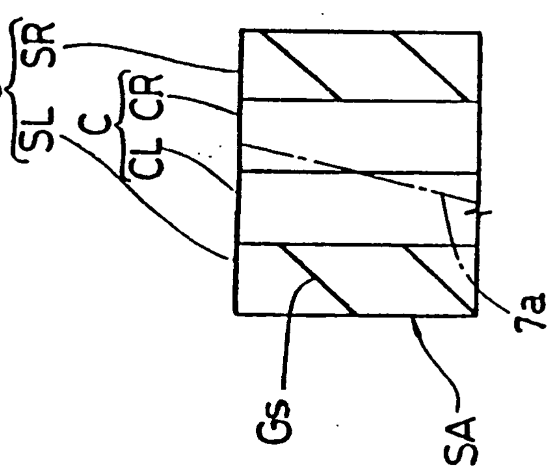


FIG.11(b)

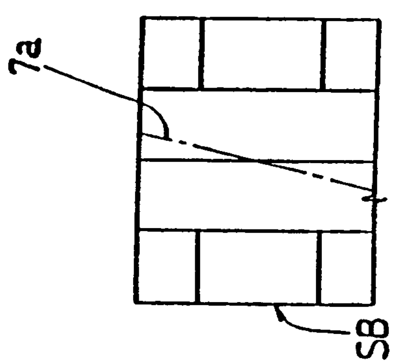


FIG.11(c)

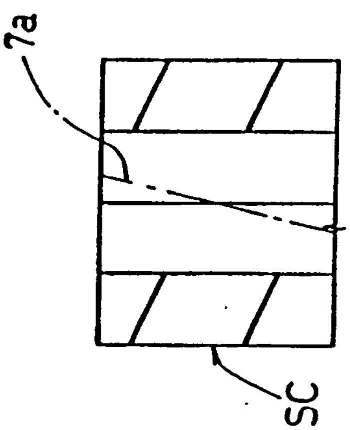


FIG.12 (a)

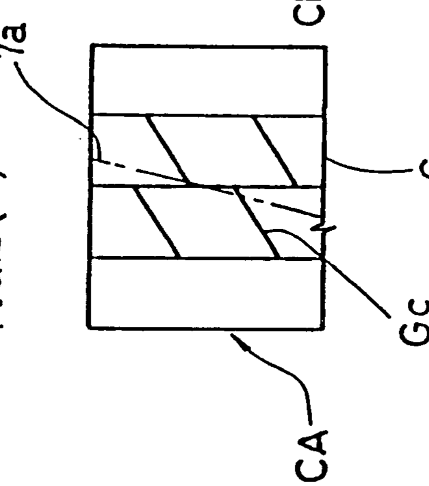


FIG.12 (b)

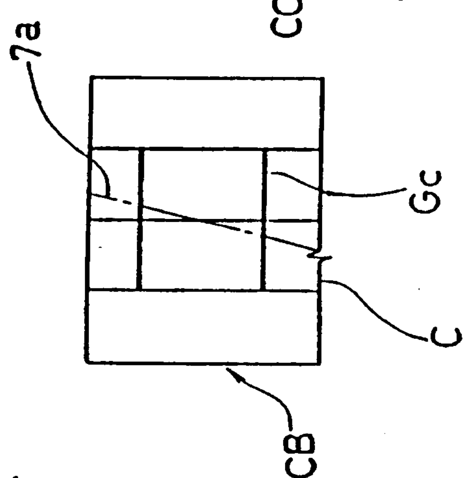


FIG.12 (c)

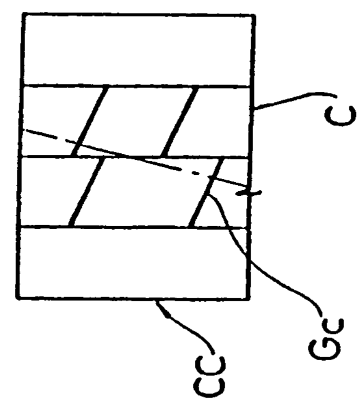


FIG.13

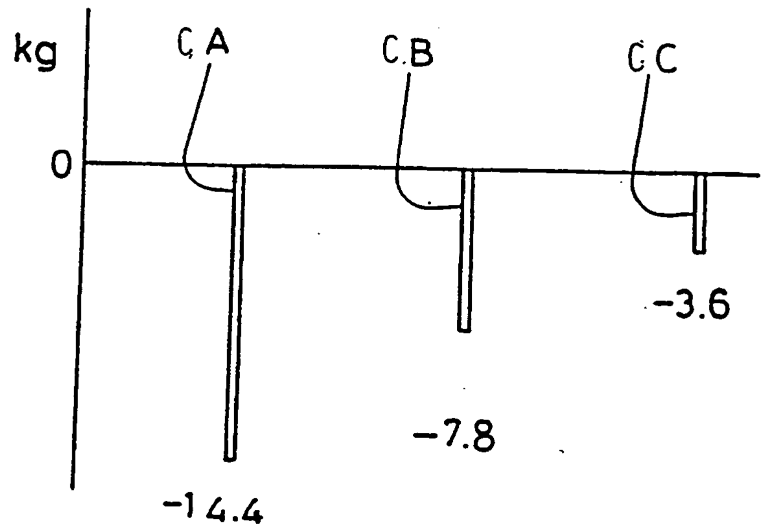


FIG.14

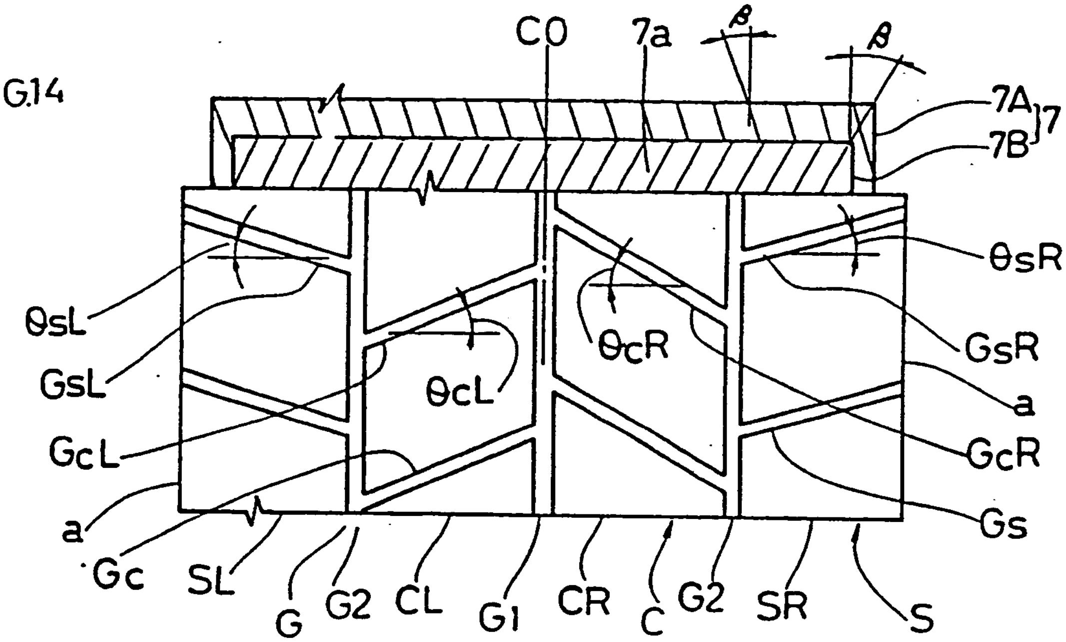


FIG.15

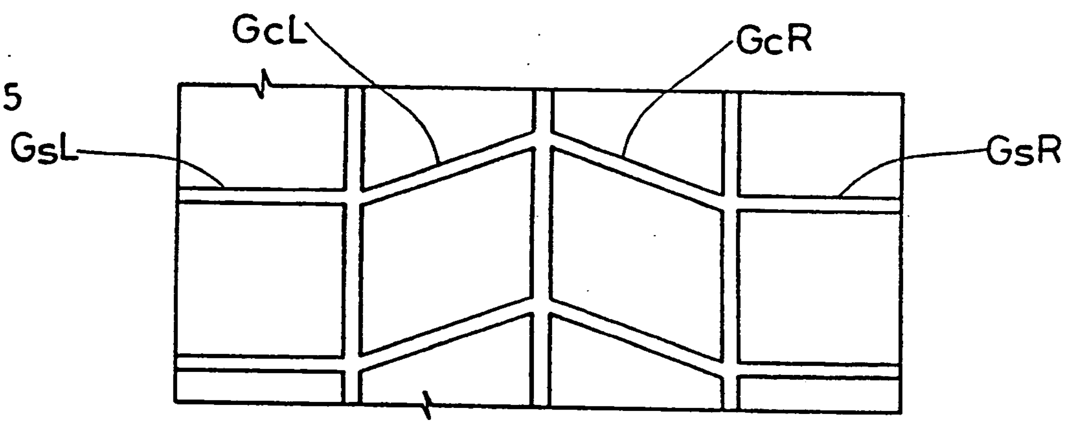


FIG.16

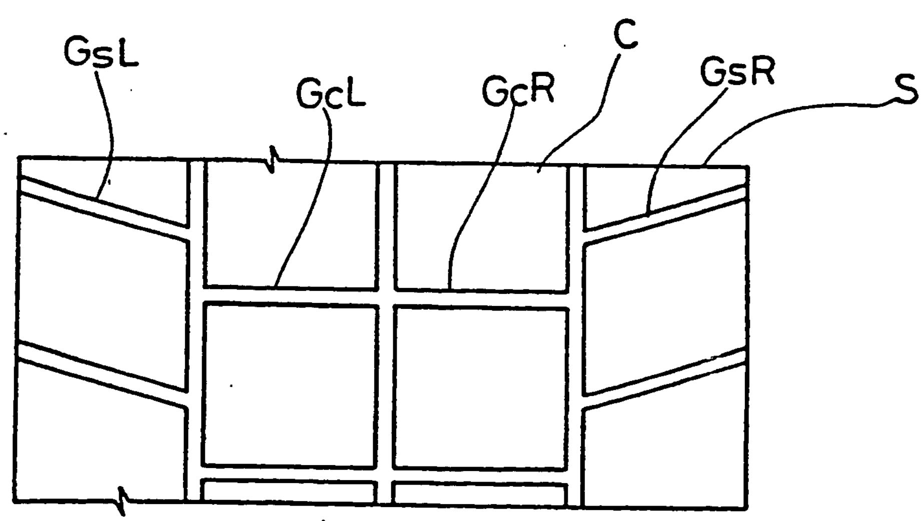


FIG.17

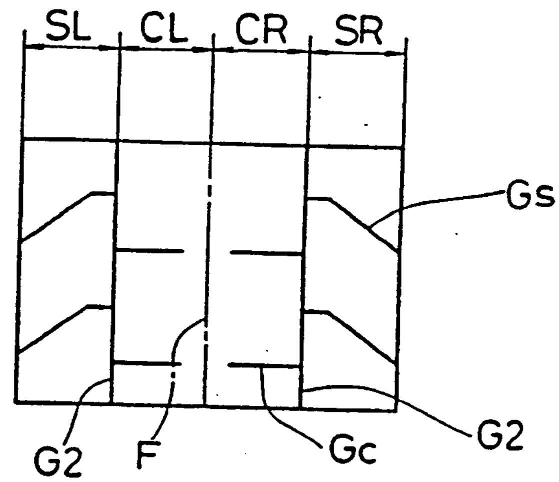


FIG.18

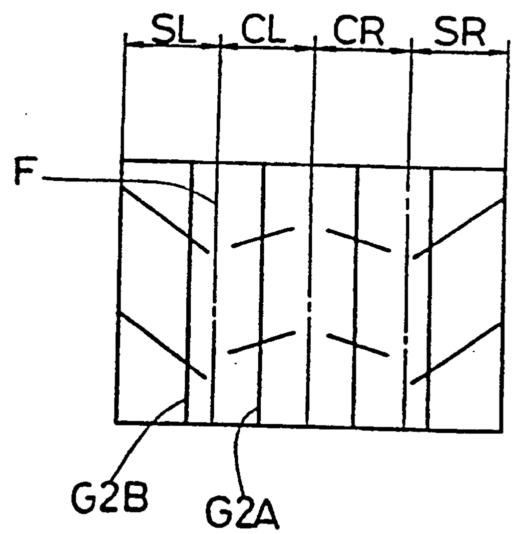


FIG.19

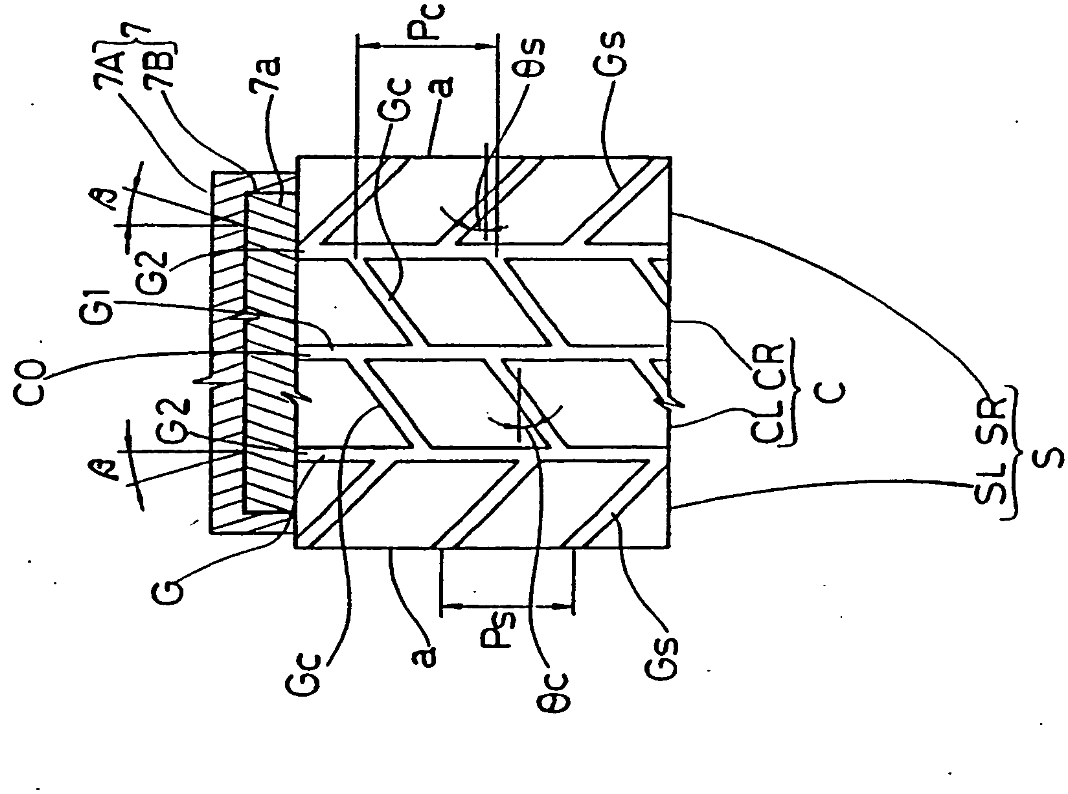


FIG.20

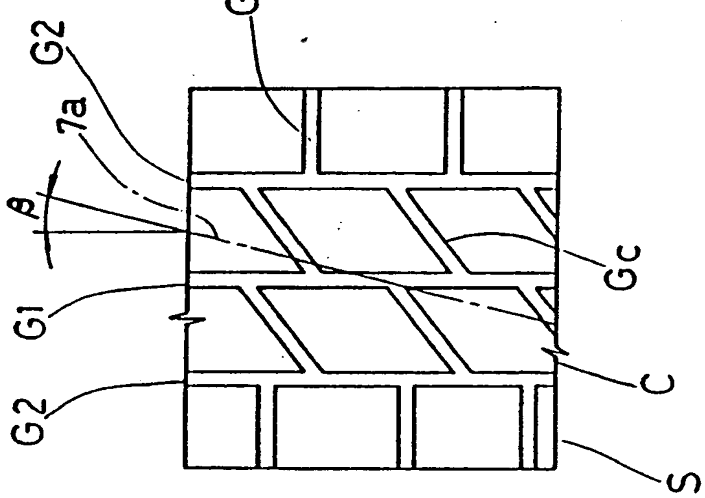


FIG.24

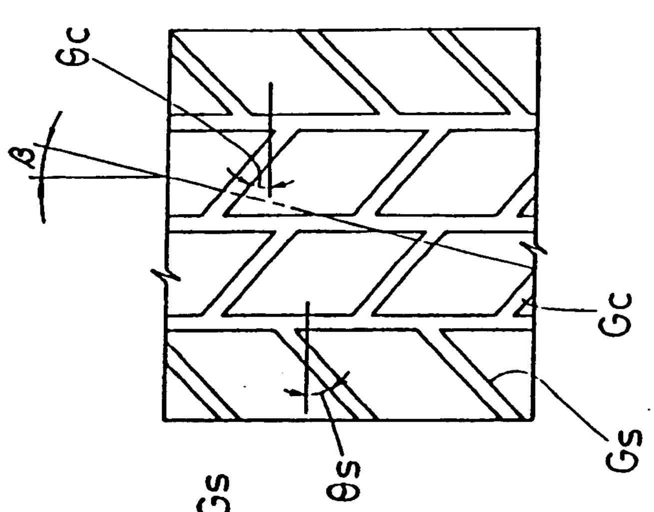


FIG.21

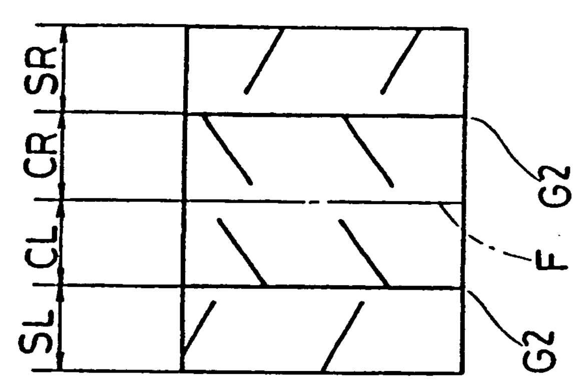


FIG.22

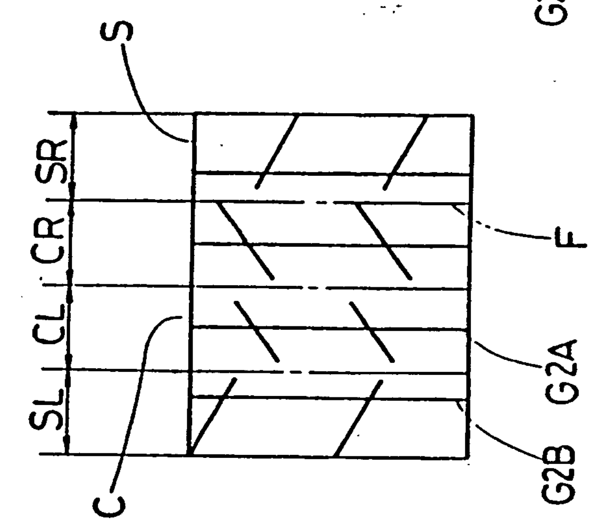


FIG.23

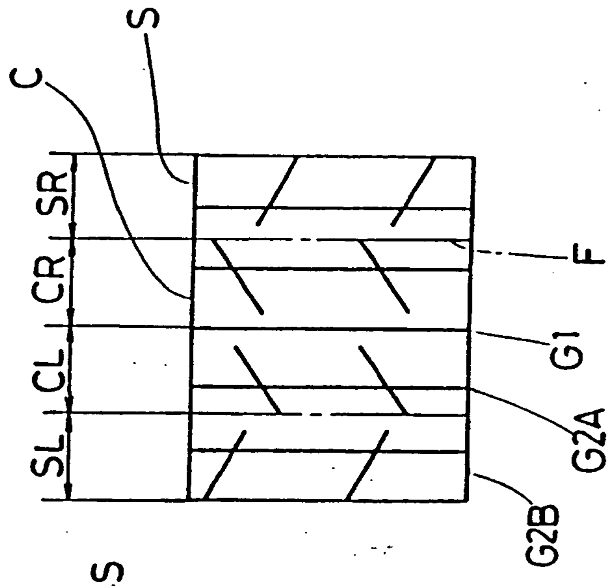


FIG.25

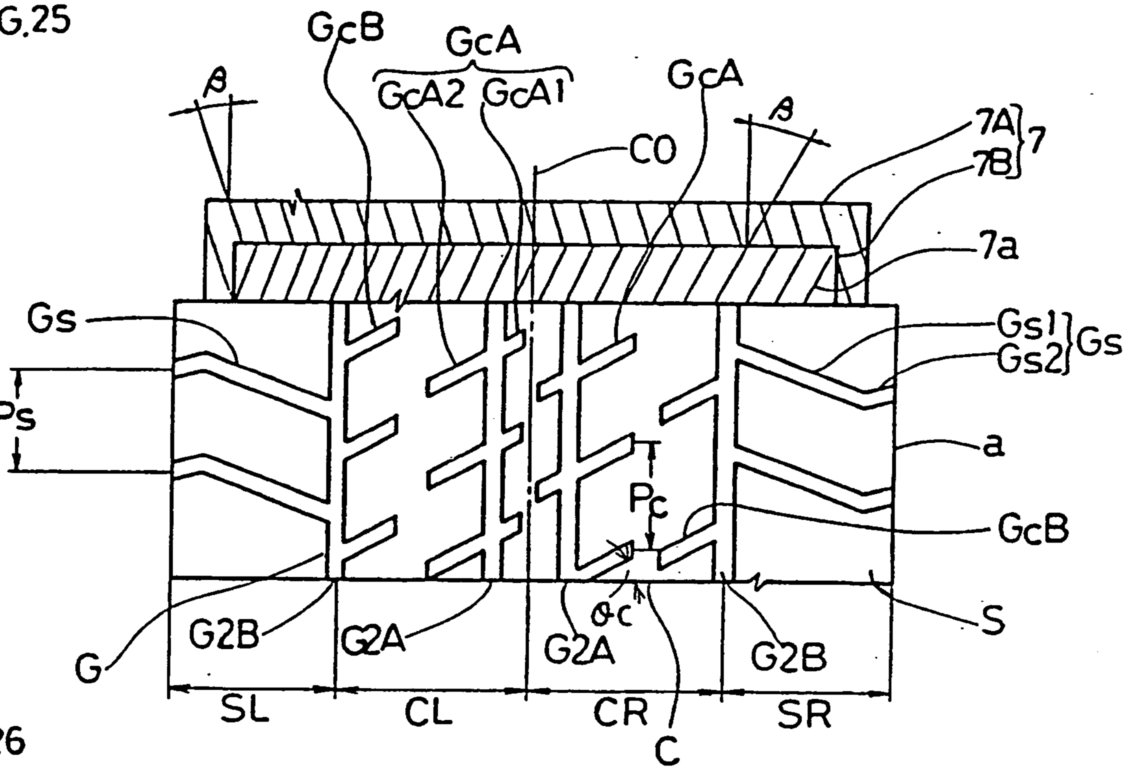


FIG.26

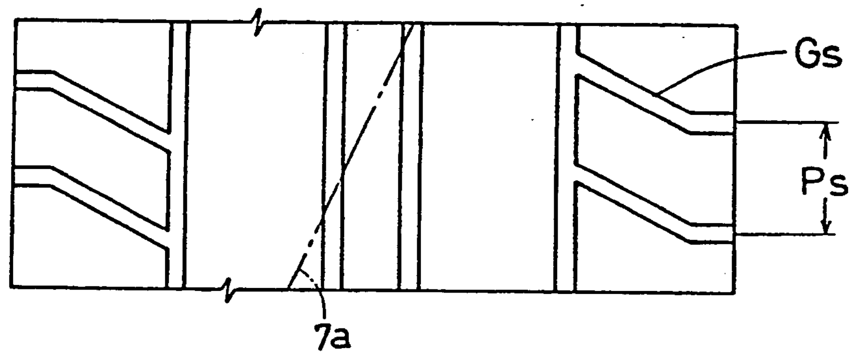


FIG.27

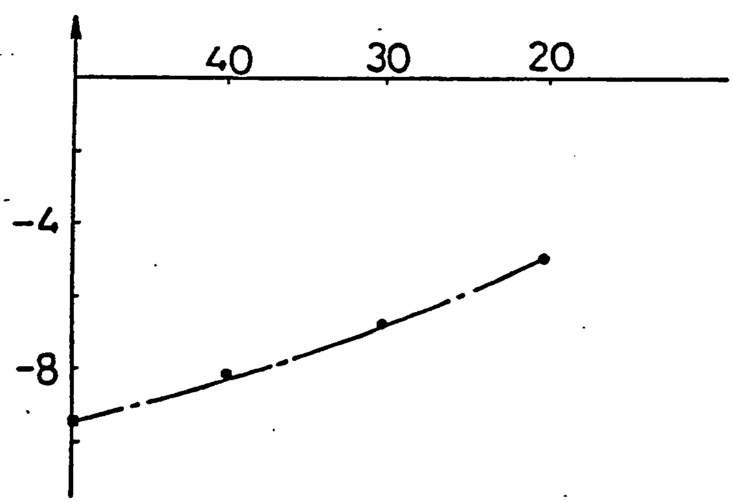


FIG.28

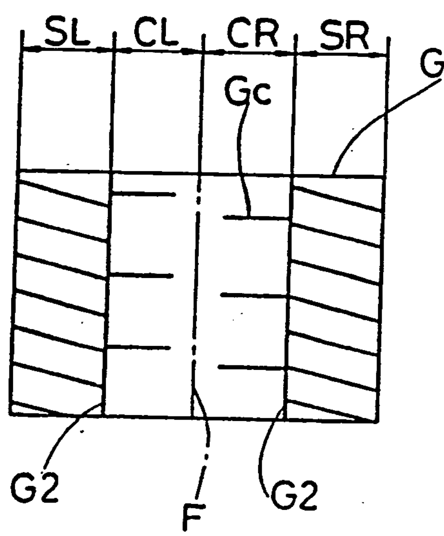


FIG.29

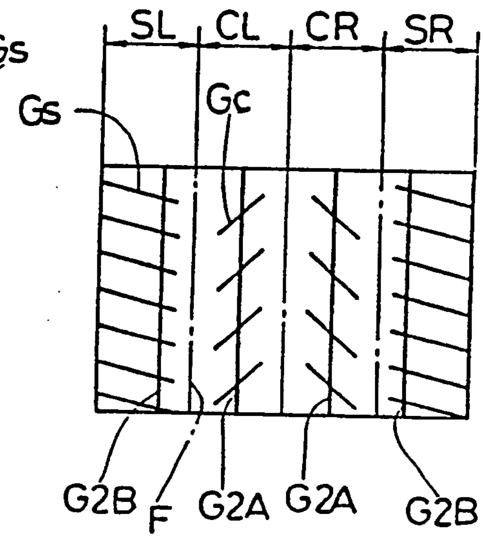


FIG.30

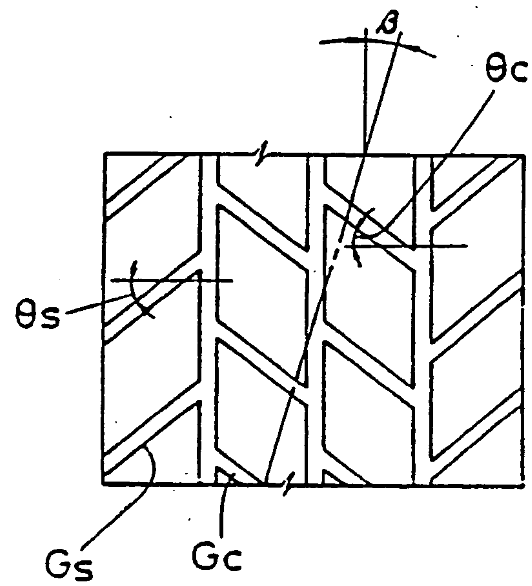


FIG.31

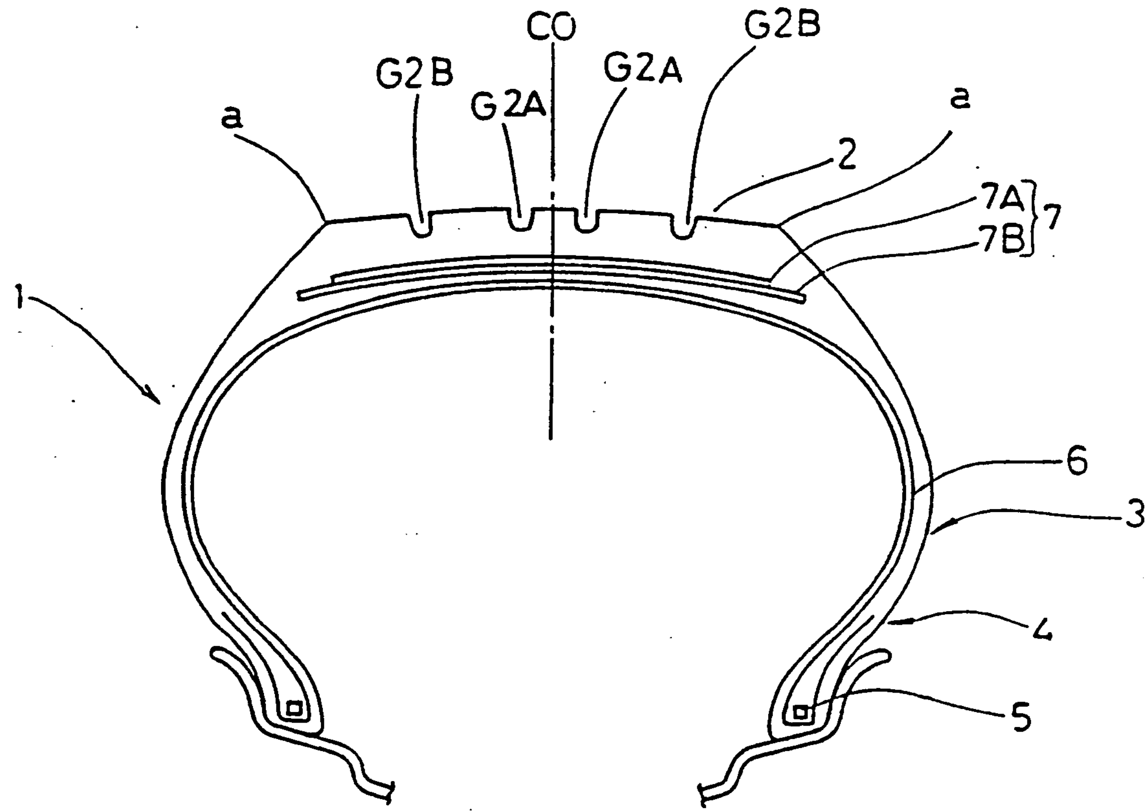


FIG.32

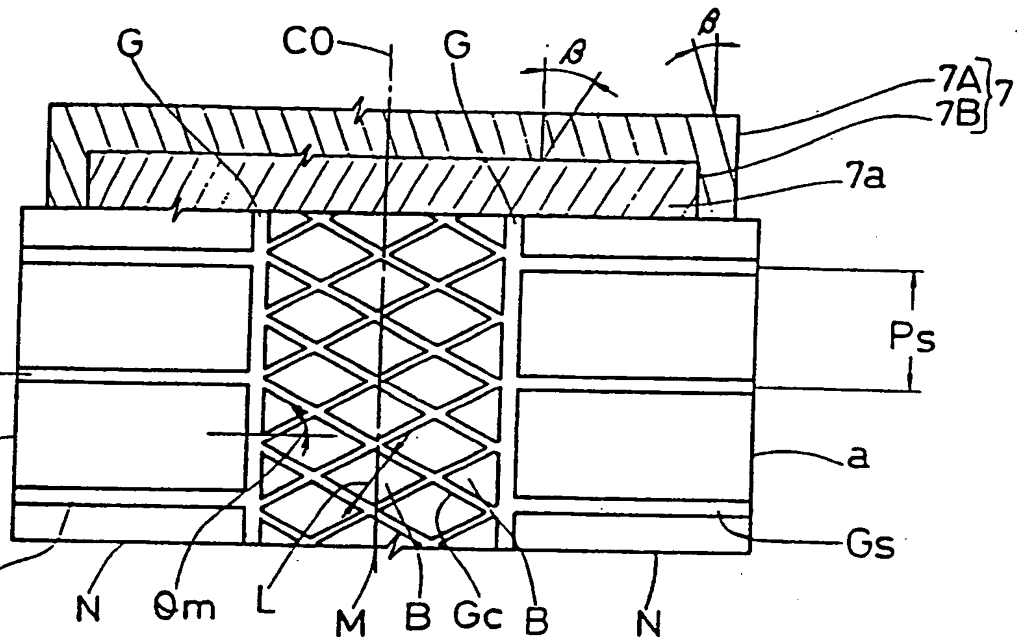


FIG.33

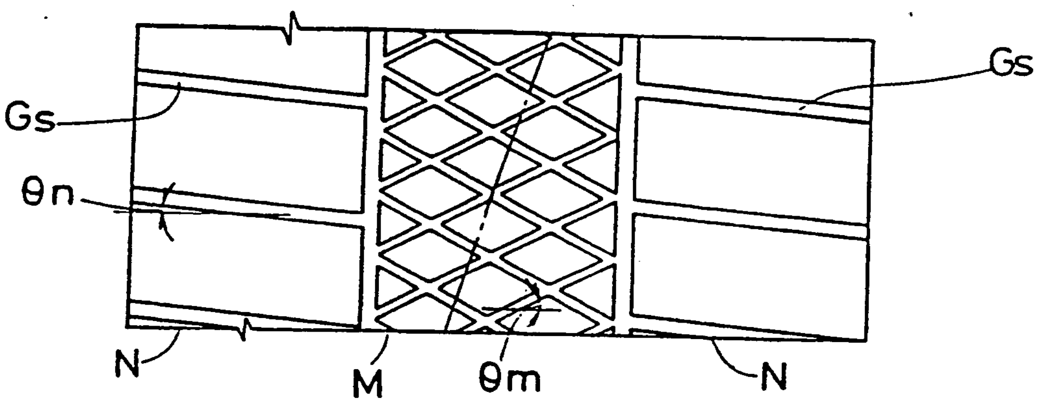


FIG.34

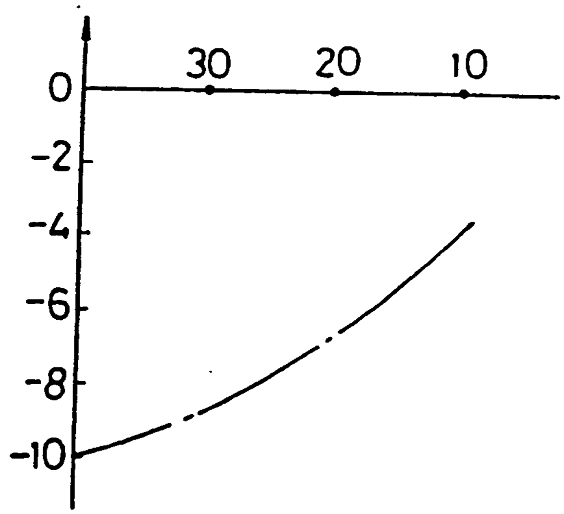


FIG.35

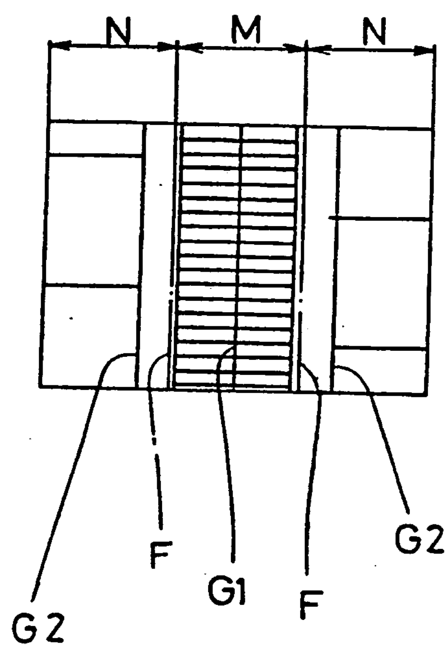
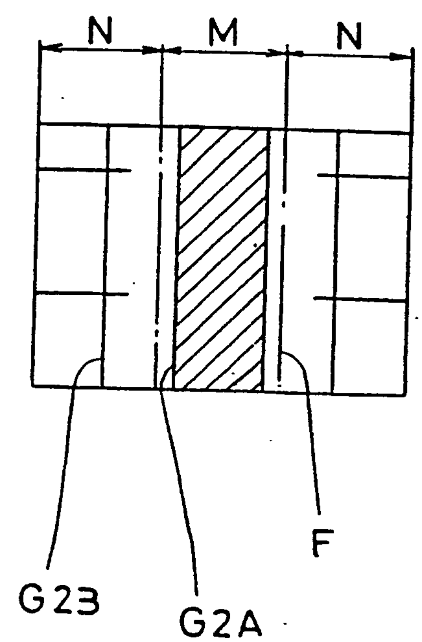


FIG.36



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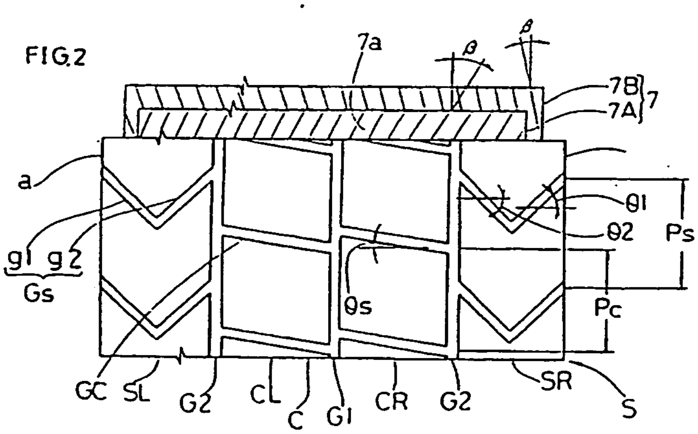
(54) **Pneumatic radial tyre.**

(57) A pneumatic radial tyre comprising a carcass (6) and a belt (7) comprising belt plies (7A, 7B) composed of steel belt cords (7a) wherein at least two circumferential grooves (G) are constructed in the tread part (2) extending continuously in the direction of the tyres equator (CO) and lateral grooves in some parts defined by dividing the tread part (2) in the axial direction of the tyre into approximately three or four equal areas. (SL, CL, CR, SR). The tyre prevents one side drifting of a car in driving and improves the straight forward driving performance.

FIG.2



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EUROPEAN SEARCH REPORT

Application Number

EP 89 31 2436

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	EP-A-0 157 716 (GOODYEAR TIRE & RUBBER CO.) * Claims 6-8; figures 2,3 *	1,5,9	B 60 C 11/11 B 60 C 9/20
A Y	US-A-4 730 654 (TAKAHASHI YAMASHITA et al.) * Column 3, lines 62-68; figure 1 *	2,4,6,8,10 1	
A	FR-A-1 548 673 (UNIROYAL ENGLEBERT FRANCE) * Figure 5a; page 3, column 1, lines 33-60 *	1	
A	EP-A-0 237 462 (GOODYEAR) * Figure 2; claims 1-4,10-13 *	2,4,6,8,10	
X	EP-A-0 196 161 (SP TYRES UK LTD) * Figures 1,5; claims 1-7 *	3	
Y	FR-A-2 388 685 (MICHELIN & CIE) * Figures 2,4; page 6, line 9 - page 7, line 3 *	5	
P,X	US-A-4 819 704 (MAKOTO MISAWA et al.) * Claims 1-4; figures 1,5A,5B,5E *	7	**TECHNICAL FIELDS SEARCHED (Int. Cl.5)**
P,X X	PATENT ABSTRACTS OF JAPAN, vol. 12, no. 212 (M-710)[3059], 17th June 1988; & JP-A-61 156 129 (YOKOHAMA RUBBER CO., LTD) 21-01-1988	9 7	B 60 C

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	28 November 90	BARADAT J.L.F.

CATEGORY OF CITED DOCUMENTS

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